A Marked Up Version Of The Amended Claims

9. (amended) In a method in constructing a multipass pump head for DPSS lasers, fiber lasers and fiber amplifiers, capable of realizing intense uniform pumping and producing and amplifying coherent light, comprising the steps of

A. selecting a pump source means, from the group consisting of a diode bar means and a multiple-pump-source means having a single pump wavelength or multiple pump wavelengths, to provide a relevant pumping light for pumping;

B. selecting a laser medium means from the group including

(1) laser chips, laser rods and laser slabs, made from regular laser materials or tunable laser materials, and

(2) optical fibers with a rare-earth-doped core;

C. setting a coupling manner to couple said pumping light to a pump entrance means including at least one pump entrance for the input of said pumping light into said multipass pump head; and

D. constructing said multipass pump head by use of a multipass formation to confine said pumping light, wherein said pumping light, once entering, undergoes multiple reflections and multiple travels through or within said laser medium means, said multipass formation is selected from the group consisting of

(1) a first multipass formation with the use of optical total-internal-reflection configuration, which additionally comprises the steps of making said multipass pump head as a TIR-guide pump head by mean of an optical duct means, leading to confining said pumping light within said TIR-guide pump head mainly via total-internal-reflection during the entire pumping process; wherein said pumping light, once entering said pump head and said optical duct means, will undergo zig-zag optical paths, multiple reflections and multiple travels through or within said laser medium means until it is absorbed, and ii) the escape loss possibility of unabsorbed said pumping light is at least less than 40% within one round trip pumping path, or at least less than 40% during the entire pumping process; whereby i) significantly reducing multiple reflection losses caused by the zig-zag optical paths, ii) confining said pumping light within said pump head to achieve effective and efficient uniform pumping; and iii) with the use of said optical duct means, eliminating hot spot issue caused by directly diode bar pumping for DPSS lasers;

(2) a second multipass formation with the use of optical graded-index or step-index configuration,

(3) a third multipass formation with the use of a noncircular-profile reflector means which has a noncircular cross-section with a convex and closed boundary, wherein i) said laser medium means is a laser rod means which has a lasing axis and a transverse plane perpendicular to said lasing axis, said noncircular cross-section is in said transverse plane, ii) said laser rod is surrounded by a cooling channel, and iii)

the maximum dimension inside said noncircular cross-section is at least four-times larger than the diameter of said laser rod means,

(4) a fourth multipass formation with the use of a double-layer reflector means,

(5) a fifth multipass formation with the use of optical spatial filter or the like configuration,

(6) a sixth multipass formation with the use of a reflector means, wherein i) said laser medium means is a laser slab means which has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut, ii) said laser slab means is cooled via said two major surfaces only , iii) said diode bar means comprises at least one linear array laser diode bar or 2-D stacked diode bar, iv) each said pump entrance receives said pumping light from one or several said diode bars without fiber coupling, and v) said pump light enters said reflector means and multiply passes through said laser slab means via said two major surfaces,

(7) a seventh multipass formation with the use of a noncircular-profile reflector means which has a noncircular cross-section, wherein i) said laser medium means is a laser slab means which has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut, ii) said laser slab means is mounted into a laser slab assembly means without O-rings, preferably via a silicone RTV, in which said laser slab means is sandwiched between two coolant passages via said two major surfaces, iii) the flow direction along said coolant passages is perpendicular to said minor surfaces of said laser slab, and iv) said pump light enters said noncircular-profile reflector means and multiply passes through said laser slab means via said two major surfaces,

(8) an eighth multipass formation with the use of an optical duct means, wherein

a) said laser medium means is a laser slab means which has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut,

b) said optical duct means consists of two members of thin planar optical duct at least, each one has two broad surfaces,

c) said laser slab means is sandwiched between said two members of thin planar optical duct via said major surfaces firstly, and then sandwiched between two heat sinks via said two members of thin planar optical duct symmetrically,

d) said optical duct means is optically coupled to two said major surfaces of said laser slab means via its said broad surfaces where said pumping light runs into said laser slab means along zig-zag optical paths,

e) said optical duct means is of high thermal conductivity and thermally in contact with said two heat sink via its said broad surfaces, said laser slab means is conductively cooled via said optical duct means,

f) in order to preserve the TIR interface for the laser zig-zag path within said laser slab means, an approach is selected from the group including: i) said laser slab means has a protective coating, and ii) said optical duct means has a lower refractive index than that of said laser slab means,

g) optionally the end of said thin planar optical duct adjacent to said laser slab means is gold coated but not square-cut in order to change the incident angle of said pumping light for effective pumping,

h) optionally said heat sink has a mirrored surface which is interfaced with said broad surfaces of said thin planar optical duct whereby to reflect said pumping light and realize multipass pumping,

i) optionally part of the additional members of optical duct have a tapered shape, and

j) optionally lateral sides of said optical duct have a gold coating in order to reflect said pumping light while said optical duct means has a low refractive index,

(9) a ninth multipass formation with the use of an optical duct means, wherein

a) said laser medium means is a laser slab means which has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut,

b) one said major surface of said laser slab means is interfaced with said optical duct means, the other one of said major surfaces is conductively cooled,

c) said pumping light, once entering said optical duct means, will undergo zig-zag optical paths, multiple reflections and multiple travels through said laser slab means until it is absorbed;

d) said pumping light enters said laser slab means via its major surface,

e) for the cooling side of said slab means, in order to reflect pumping light and to preserve the TIR interface for the laser zig-zag path within said laser slab means, an approach is selected from the group including: i) it is covered by a metal foil which may have a high reflectivity, ii) it is interfaced with a metalized mirror surface of a heat sink, and iii) it is HR coated at the pump wavelength, and the SiO_2 or MgF_2 material is used as the first layer of the HR coating,

f) for the non-cooling side of said slab means, in order to preserve the TIR interface for the laser zig-zag path within said laser slab means, an approach is selected from the group including: i) it has a protective coating or bonding material, ii) it has a MgF_2 window, iii) said optical duct has a lower refractive index than said slab means, and iv) it is distanced from said optical duct means with an interstitial air,

g) optionally one side of said optical duct has a gold coating in order to reflect said pumping light, and

h) optionally part of said optical duct means have a tapered shape, and

(10) a tenth multipass formation with the use of a reflector means, wherein i) said laser medium means is an optical fiber means with a rare-earth-doped core, ii) said diode bar means comprises at least one linear array laser diode bar or 2-D stacked diode bar, iii) said pumping light from one or several said diode bars are optically coupled to one said pump entrance, and iv) said pump light enters said reflector means and multiply passes through said optical fiber means; and

E. housing and cooling said laser medium means.

[Note] In order to protect the present invention properly and thoroughly, above five additional multipass formations are added without introducing the "new matter". The newly added sixth multipass formation is

typically presented in Figs. 3A-B, Figs. 4A-B and Figs. 4C-D. The newly added seventh multipass formation is typically presented in Figs. 16A and Figs. 17A. The newly added eighth multipass formation is typically presented in Figs. 15N-O, 15P-Q and 15R-S. The newly added ninth multipass formation is typically presented in Figs. 14A-D. The newly added tenth multipass formation is typically presented in Figs. 19A-D.

10. In constructing said TIR-guide pump head by use of said first multipass formation as recited in claim 9, in order to make a slab laser pump head of said TIR-guide pump head for zig-zag slab lasers, further comprising the steps of

A. making a laser slab means of said laser medium means, wherein said laser slab means has a substantially rectangular cross section with two major surfaces, two minor surfaces, and two opposing end faces which are cut at a Brewster angle or square-cut;

B. predetermining the location and orientation for said laser medium means, said optical duct means and pump entrance means in effective operative relationship, whereby facilitating the multipass pump process, minimizing the escape loss and obtaining efficient and uniform pumping;

C. optimizing the optical and physics properties and performance parameters of said pump head in effective operative way, including the profile, size, geometric shape, refractive index and dopant concentration, whereby facilitating efficient and uniform pumping, laser operation and effective cooling;

D. in order to protect the TIR interfaces for said TIR-guide pump head, selecting an approach from the group including:

(1) by use of a mental foil or pressed mental layer, including aluminum, indium and silver foil,

(2) by use of a thick metal coating,

(3) by use of a metalized mirror surface,

(4) by use of a coating or film with a low refractive index, including cement J91, silicon gel, optical-grade epoxy, SiO_2 coating and Teflon AF 1600 coating, and

(5) by use of a clear optical window with a low refractive index, including MgF_2; and

E. selecting said slab laser pump head from the group including:

(1) a first slab laser pump head, wherein

a) said pump light enters and multiply passes through said laser slab means via said two major surfaces, and

b) said laser slab means is sandwiched between two coolant passages via said two major surfaces, said coolant passage is formed between said optical duct means and said laser slab means;

(2) a second slab laser pump head, wherein

a) said pump light enters and multiply passes through said laser slab means via at least one said major surface until said pumping light is absorbed, and

b) said laser slab means is sandwiched by and in contact with said optical duct means via its two major surfaces, said optical duct is of high thermal conductivity for heat transfer and effective cooling;

(3) a third slab laser pump head in which said laser slab means is conductively cooled, wherein

a) said pumping light enters said laser slab means via said major surface of said laser slab means,

b) one said major surface of said laser slab means is interfaced with said optical duct means, the other one of said major surfaces is conductively cooled,

c) in order to reflect pumping light and to preserve the TIR interface for the laser zig-zag path within said laser slab means, one of the following procedures is selected for the cooling side of said slab means: i) it is covered by a metal foil which may have a high reflectivity, ii) it is interfaced with a metalized mirror surface of a heat sink, and iii) it is HR coated at the pump wavelength, and the SiO_2 or MgF_2 material is used as the first layer of the HR coating, and

d) in order to preserve the TIR interface for the laser zig-zag path within said laser slab means, one of the following procedures is selected for the non-cooling side of said slab means: i) it has a protective coating or bonding material, ii) it has a MgF_2 window, and iii) it is distanced from said optical duct means with an interstitial air;

(4) a fourth slab laser pump head in which said laser slab means is conductively cooled, wherein

a) said optical duct means consists of one or two members of thin slab-shaped optical duct which has a substantially rectangular cross section and two broad surfaces,

b) said optical duct means is interfaced with at least one major surface of said laser slab means via its said broad surface where said pumping light enters into said laser slab means along zig-zag optical paths,

c) said optical duct means is of high thermal conductivity,

d) in order to preserve the TIR interface for the laser zig-zag path within said laser slab means, one of the following procedures is selected: i) said laser slab means has a protective coating, and ii) said optical duct means has a lower refractive index than that of said laser slab means, and

e) at least one said major surface of said laser slab means is conductively cooled via said optical duct means;

(5) (amended) a fifth slab laser pump head in which said laser slab means is conductively cooled, wherein

a) said optical duct means consists of at least two members of thin planar optical duct, each one has two broad surfaces,

b) said laser slab means is sandwiched between said two members of thin planar optical duct via said major surfaces firstly, and then sandwiched between two heat sinks via said two members of thin planar optical duct symmetrically,

c) said optical duct means is interfaced with two said major surfaces of said laser slab means via its said broad surfaces where said pumping light enters into said laser slab means along zig-zag optical paths,

d) said optical duct means is of high thermal conductivity and thermally in contact with said two heat sink via its said broad surfaces, said laser slab means is conductively cooled via said optical duct means,

e) in order to preserve the TIR interface for the laser zig-zag path within said laser slab means, one of the following procedures is selected: i) said laser slab means has a protective coating, and ii) said optical duct means has a lower refractive index than that of said laser slab means,

f) optionally said heat sink has a mirrored surface which is interfaced with said broad surfaces of said optical duct means whereby to reflect said pumping light and realize multipass pumping,

g) optionally the end of said thin planar optical duct adjacent to said laser slab means is gold coated but not square-cut in order to change the incident angle of said pumping light for effective pumping,

h) optionally part of the additional members of optical duct have a tapered shape, and

i) optionally lateral sides of said optical duct have a gold coating in order to reflect said pumping light while said optical duct means has a low refractive index;

(6) a sixth slab laser pump head with the so-called edge pumping in which said laser slab means is conductively cooled, wherein

a) said pumping light enters said laser slab means via at least one said minor surface along zig-zag optical paths,

b) said optical duct means is interfaced with at least one said minor surface of said laser slab means via a transparent bonding material or interstitial air, and

c) said laser slab means is conductively cooled via its two major surfaces;

(7) a seventh slab laser pump head in which said laser slab means is conductively cooled, wherein

a) said laser slab means is extra-thin with a thickness of less than 1 mm, more particularly less than 0.5 mm,

b) said laser slab means is integrated with or embedded into said optical duct means,

c) said laser slab means has a line-shaped gain region,

d) said optical duct means is transparent at both the pump and laser wavelengths and its refractive index is the same as or close to that of said laser slab means,

e) a joint approach is used, including, i) a high temperature, optical-grade epoxy or glue interposed between said laser slab means and said optical duct means, ii) diffusion-bonding, and iii) frit,

f) the lasing direction is perpendicular to said line-shaped gain region, and

g) said slab laser means together with said optical duct means is conductively cooled via an HR mirror or mirrored surface, said mirror has thin substrate with high thermal conductivity, made from the group including copper, sapphire, undoped YAG and MgF_2, said HR mirror serves as a rear or fold mirror for laser operations, its other side is going to contact a heat sink via a metal foil and heat spreader sometimes optionally; and

(8) a eighth slab laser pump head in which said laser slab means is conductively cooled, wherein

a) said laser slab means has a line-shaped gain region,

b) said optical duct means is transparent at pump wavelengths,

c) the lasing direction is along said line-shaped gain region,

d) said optical duct means is interfaced with said laser slab means via a transparent bonding material or interstitial air, and

e) said slab laser means is conductively cooled via its two major surfaces covered by a metal foil and heat spreader which is preserved for total-internal-reflection.

To amend claim 1, D as follows: page 56

line 18, after "an one-dimensional" add --- prism ---.

To amend claim 2, A as follows: page 57

Line 4, change "undergoes" to --- will undergo ---.

To amend claim 13, B as follows: page 69

Line 12, before "surrounded" add ---optionally---.

To amend claim 25 as follows: page 76

line 21-22, change "and 1-W CW blue coherent light" to --- or blue coherent light ---.

To amend claim 26 as follows: page 77

line 16, after "disk lasers" add --- or multipass light amplifiers ---.

To amend claim 30 as follows page 80

line 22-23, change "and 1-W CW blue coherent light" to --- or blue coherent light ---.